Optimization of jet energy resolution

To avoid any confusion let me stress that here I don't try establish a procedure to calibrate or optimize the real calorimeter. Instead I study the performance of our simulated detector which is to some extent approximates the real one.

In my optimization procedure I consider three weights, so that a reconstructed jet 4-momentum is defined as

$$P_{\mathrm{rec}} = w_{\mathrm{e}} P_{\mathrm{e}} + w_{\mathrm{h0}} P_{\mathrm{h0}} + w_{\mathrm{h}} P_{\mathrm{h}}$$

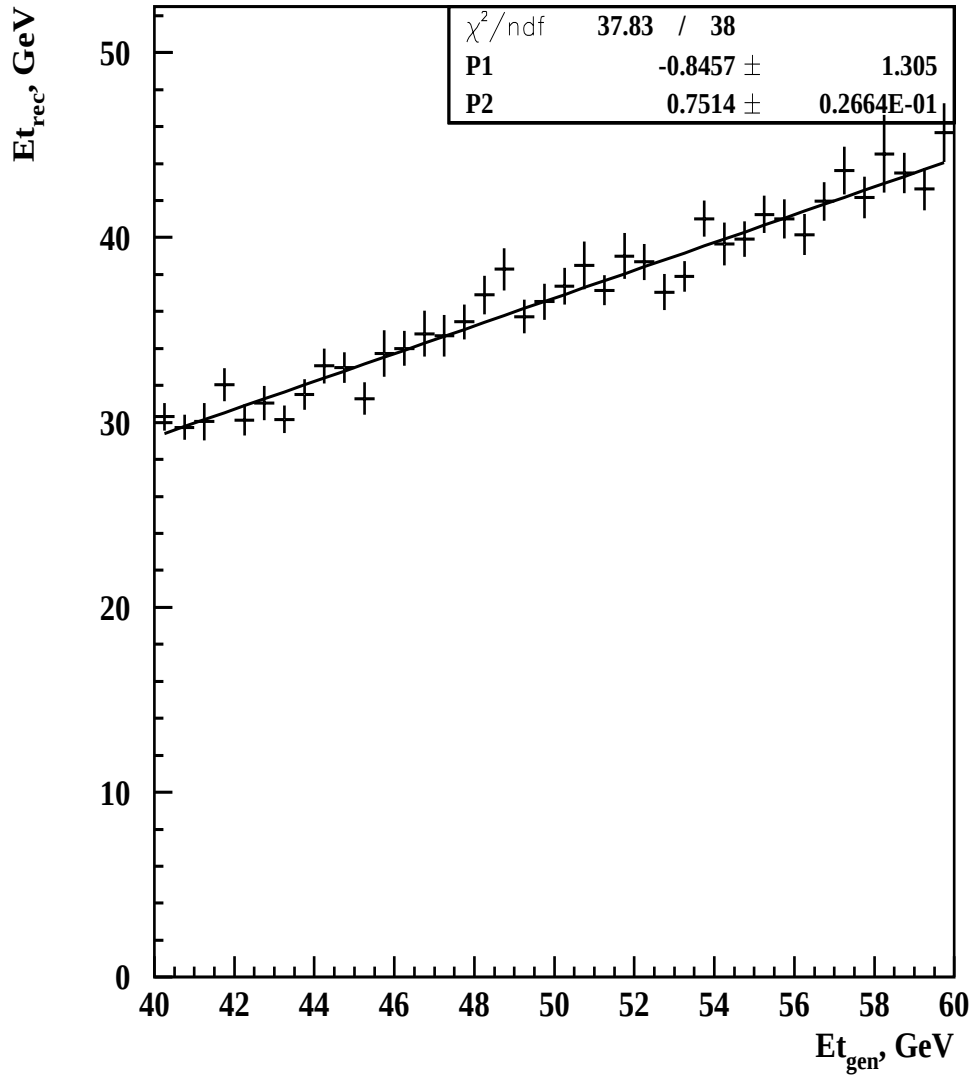
where P_{e}, P_{h0}, P_{h} are jet 4-momenta reconstructed in the ECAL, the first HCAL layer and in the rest of the HCAL respectively.

Jet transverse energy is then calculated as

$$Et_{\mathrm{rec}}(w) = E_{\mathrm{rec}}(w) \sin\theta_{\mathrm{rec}}(w)$$

where w stands for the whole set of weights.

I try to independently optimize the energy resolution at several values of Et and η.
At each such point I vary w_{e} and w_{h0} and keep $w_{\mathrm{h}} = 1$.



For each set of weights used in my optimization procedure I locally calibrate the calorimeter by fitting $(Et_{\text{rec}}, Et_{\text{gen}})$ data with a linear function

$$Et_{\text{rec}} = p1 + p2 \cdot Et_{\text{gen}}$$

where Et_{gen} is the generator particle level jet energy. From the fits I get p1(w) and p2(w).

Now,

$$Et_{\text{corr}}(w) = \frac{Et_{\text{rec}}(w) - p1(w)}{p2(w)}$$

represents the reconstructed energy in the right scale.

Finally I scale the events with different Et_{gen} to the single energy $\langle Et_{\text{gen}} \rangle$ and calculate the energy resolution as

$$\text{RESOLUTION}(w) = \frac{\text{RMS}(Et_{\text{corr}} / Et_{\text{gen}})}{\langle Et_{\text{corr}} \rangle / \langle Et_{\text{gen}} \rangle}$$

over 20% range of Et_{gen}. In fact, as a result of the calibration $\langle Et_{\text{corr}} \rangle / \langle Et_{\text{gen}} \rangle = 1$ with an accuracy better than 1% and could be omitted.

RESOLUTION(w) as defined above is exactly the function I minimize.

Last remark:

In general, it's inadequate to compare the energy resolutions calculated as $\mathrm{RMS}(Et_{\mathrm{rec}}) \,/\, Et_{\mathrm{rec}}$ for different methods of energy reconstruction unless the energy scales are identical or differ by a constant factor.

Along with changing the energy resolution, variation of the calorimeter weights incurs additional non-linear corrections to the energy scale. The both effects contribute to the change of $\mathrm{RMS}(Et_{\mathrm{rec}}) \,/\, Et_{\mathrm{rec}}$. To exclude the latter effect I always correct on average the reconstructed energy to one and the same scale (the Et_{gen} scale) and then compare $\mathrm{RMS}(Et_{\mathrm{corr}}) \,/\, Et_{\mathrm{corr}}$.

All this said, I should mention that in my case the actual contribution of the energy scale change to the change of $\mathrm{RMS}(Et_{\mathrm{rec}}) \,/\, Et_{\mathrm{rec}}$ seems to be relatively small and probably can be ignored, but I paid no particular attention to study relative contributions of the two effects.